

JSC/EC5 U.S. Spacesuit Knowledge Capture (KC) Series Synopsis

Topic: EVA Skills Training

Date: March 6, 2012 **Location:** Johnson Space Center (JSC), Houston, Texas

Presenter: Scott Parazynski, M.D.

Synopsis: Dr. Parazynski and a colleague from Extravehicular Activity (EVA), Robotics, & Crew Systems Operations (DX) worked closely to build the EVA Skills Training Program, and for the first time, defined the gold standards of EVA performance, allowing crewmembers to increase their performance significantly. As part of the program, individuals had the opportunity to learn at their own rate, taking additional water time as required, to achieve that level of performance. This focus on training to one's strengths and weaknesses to bolster them enabled the Crew Office and DX to field a much larger group of spacewalkers for the daunting "wall of EVA" required for the building and maintenance of the ISS. Parazynski also stressed the need for designers to understand the capabilities and the limitations of a human in a spacesuit, as well as opportunities to improve future generations of space. He shared lessons learned (how the Crew Office engaged in these endeavors) and illustrated the need to work as a team to develop these complex systems.

Biography: Dr. Scott Parazynski is a physician and a physiologist with expertise in human adaptation to stressful environments, having been graduated from Stanford University and Stanford Medical School. He went on to train at Harvard University and in Denver in preparation for a career in emergency medicine and trauma. In 1992 he was selected to join NASA's Astronaut Corps and eventually flew five Space Shuttle missions and conducted seven spacewalks (EVAs). In October 2007, Parazynski led the EVA team on STS-120, a highly complex space station assembly flight, during which he performed four EVAs. The fourth and final EVA is regarded by many as one of the most challenging and dangerous ever performed. In his 17 years as an astronaut, he also served in numerous senior leadership roles, including EVA branch chief and the lead astronaut for Space Shuttle Thermal Protection System Inspection & Repair (in the aftermath of the Space Shuttle Columbia tragedy). He has the distinction of being the only person to both fly in space and stand on top of the planet, the summit of 29,035-foot Mount Everest. He served as chief technology officer and chief medical officer at The Methodist Hospital Research Institute in Houston, Texas.

Video Length (Size): 1:28:26 (0.35081 GB)

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EVA Skills Training

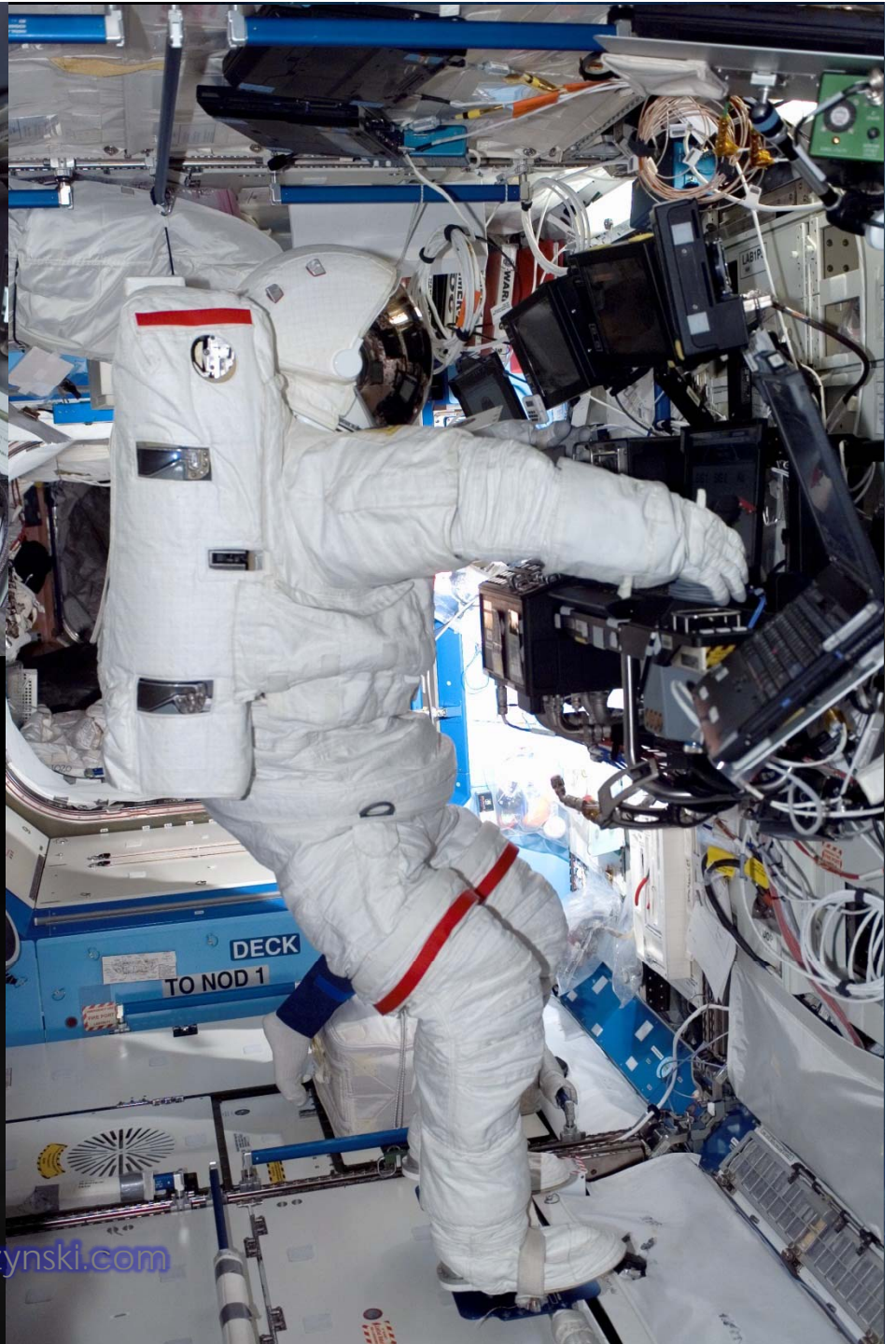


Scott Parazynski, MD

“US Spacesuit Knowledge Capture Series”

6 March 2012

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"US Spacesuit Knowledge Capture Series"

1. "EVA Physiology & Medical Considerations Working in a Suit" --- Tuesday, January 24, 2012

**2. "Real-time EVA Troubleshooting" ---
Thursday, February 16, 2012**

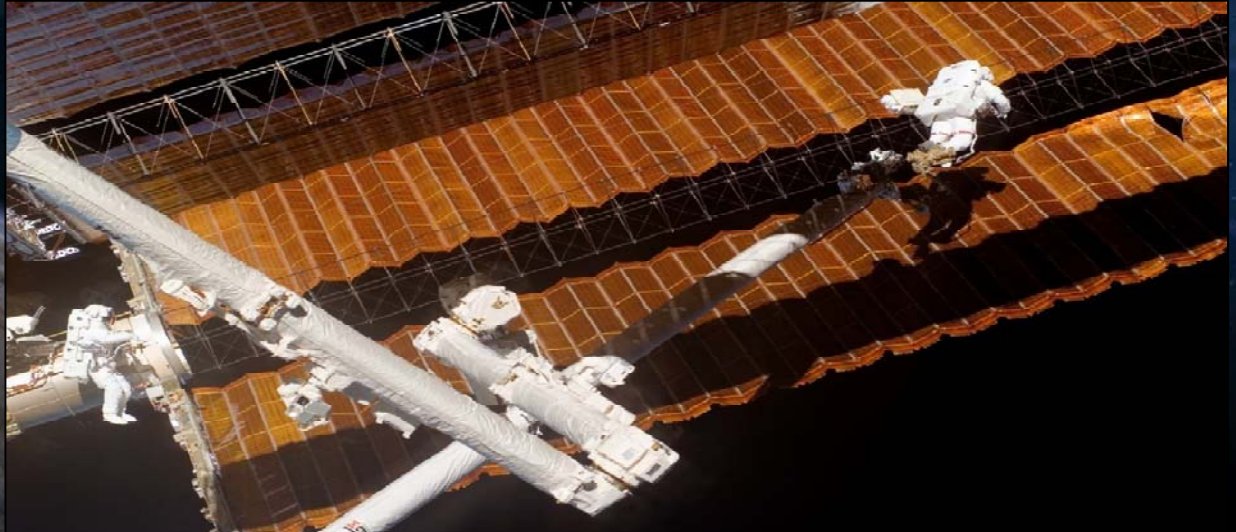
**3. "TPS Inspection & Repair" ---
Thursday, February 23, 2012**

**4. "EVA Skills Training" ---
Tuesday, March 6, 2012**

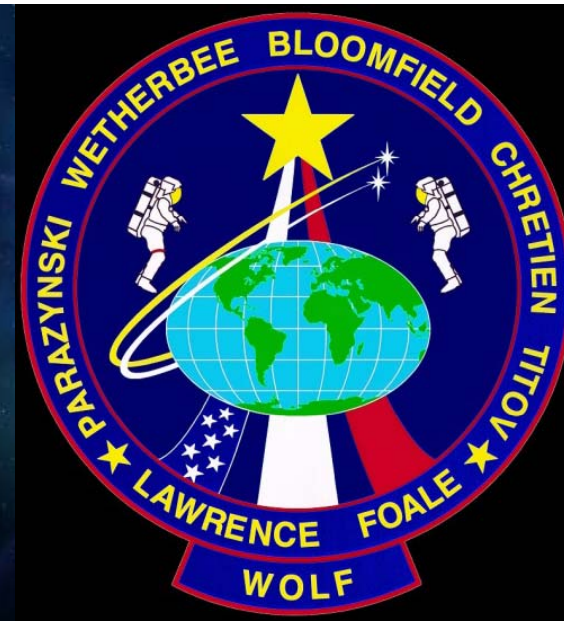
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“Parazynski” is like “Smith” or “Doe” in Poland...



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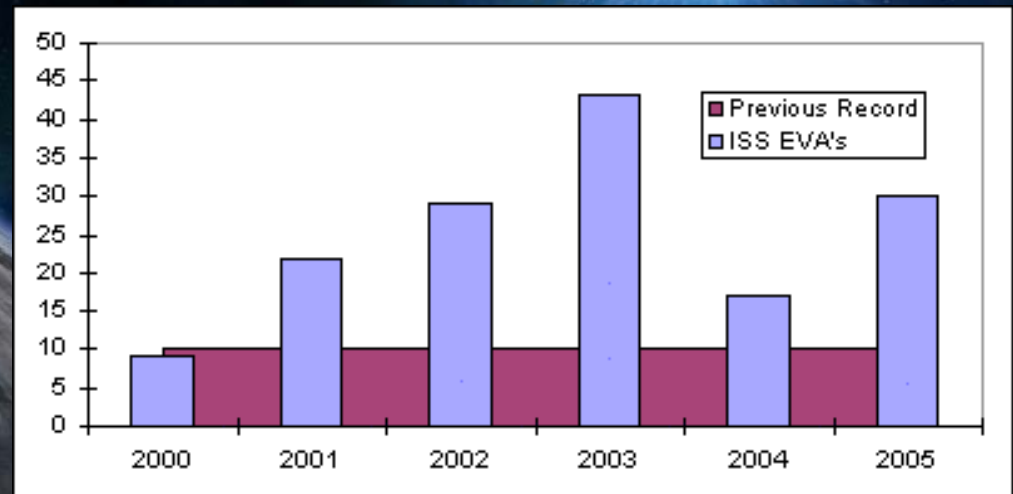


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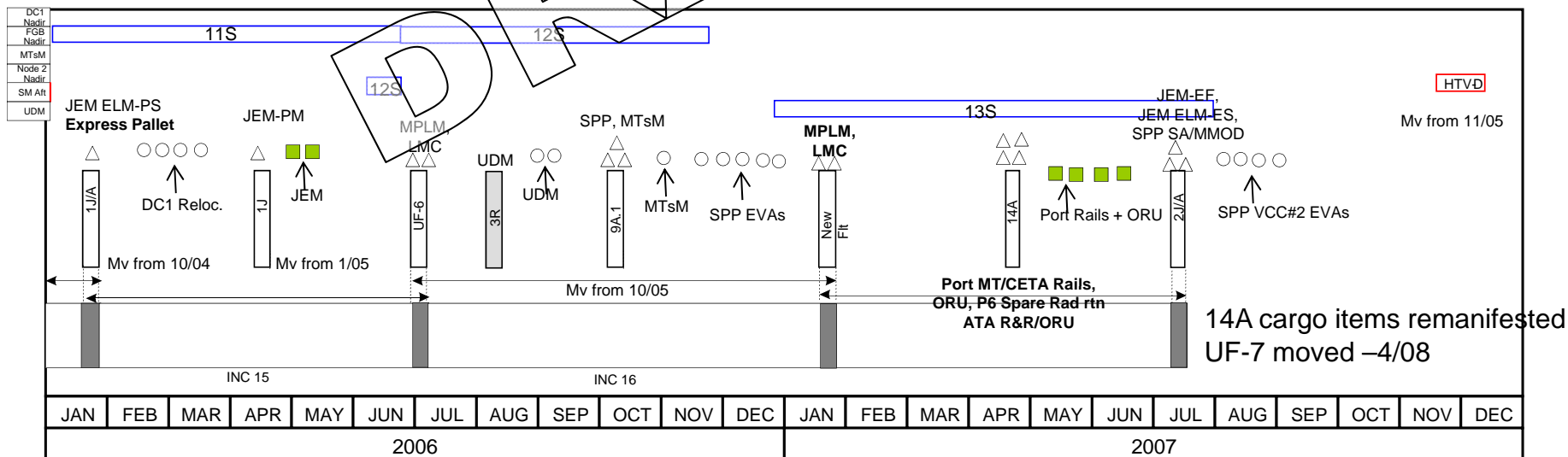
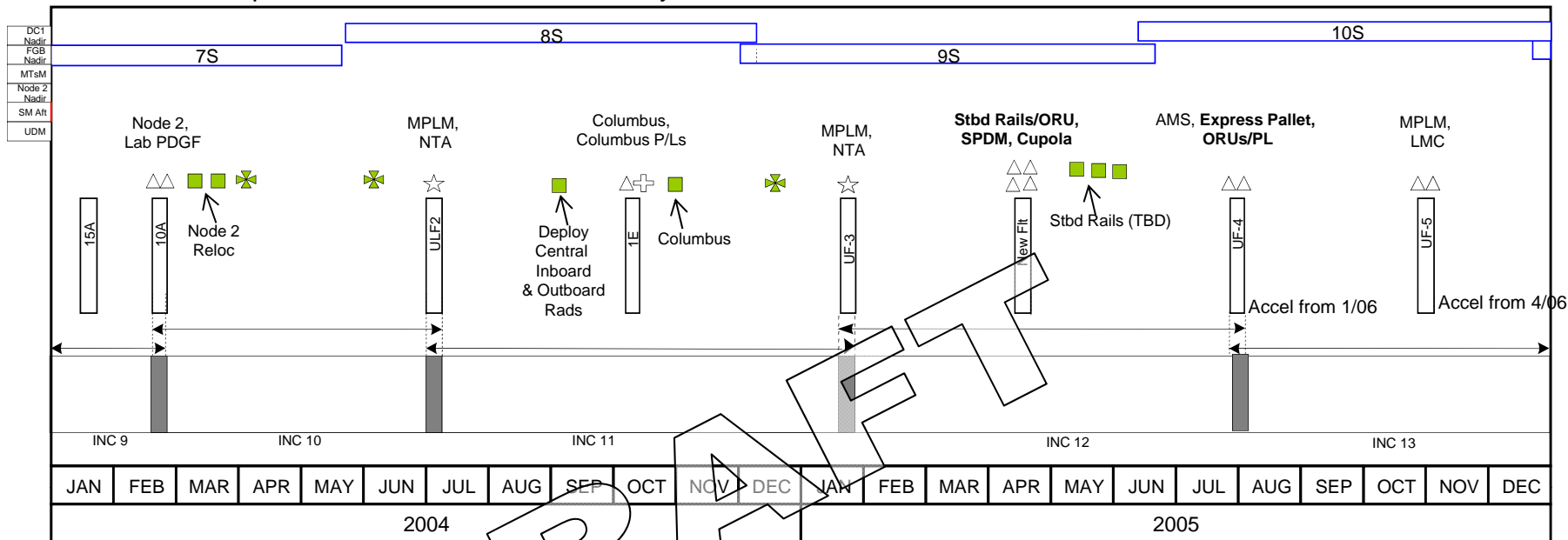


Wall of EVA: Summit Success

- ISS “Wall of EVA”: not enough qualified crew for the volume of work ahead
- Developed the “EVA Skills Training Program”
 - Defined “Gold Standards” of EVA performance
 - Gave trainees additional time to work towards these goals
 - Ultimately a huge success: ISS assembly complete, many maintenance successes by ISS crews



US Core Complete with NASDA Schedule Delays



- Shuttle Schedule is under review.
- EVA Plan is an educated guess. Based upon previous Ops Baselines assessments.
- Assumed that UDM, SPP, and MTsM is delivered in 2006. If elements are delayed, so are the associated EVAs.

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	ASSEMBLY				MAINTENANCE				SCIENCE			
	US		RUS		US		RUS		US		RUS	
Shuttle	STS	ISS	STS	ISS	STS	ISS	STS	ISS	STS	ISS	STS	ISS
Docked	△	□	N/A	○	☆	▽	N/A	✱	+	◇	N/A	×
Undocked	N/A	■	N/A	●	N/A	▼	N/A	✱	N/A	◆	N/A	✱

See One, Do One, Teach One



Invest in People (CB, DX, Engineers)



- Allocate expensive resources like NBL time & VR Lab to help future crew attain peak performance & EVA flight assignment
- Allocate additional resources to DX and EC for their familiarity with ops limitations
- Build a much larger cadre of crew, flight controllers and h/w engineers versed in EVA

EVA Skills Program Goals

- Intensive exposure to EVA techniques, teamwork & decision making
- 6-10 dedicated skills runs/student; more as req'd
- Attain peak performance by the completion of program
- Increase overall water experience (~100 hrs total)
- Increase CB familiarity with ISS EVA ops, tools & tasks
- Provide real-time feedback from experienced EVA crew & DX32
 - Runs catered to the strengths/weaknesses of the student
- Enable CB management to select from a pool of highly qualified EVA candidates
- Crew Office taking partial responsibility for training itself: paradigm shift



New Approaches to Training

- **Dedicated Skills Runs**
 - Simulate end-to-end EVA, unlike typical engineering test runs
 - Students develop their own timelines to think through the entire EVA task
 - Real-time, detailed feedback --> learning curve is incredibly steep
- **3rd Suit Runs: valuable for self-directed practice, e.g. APFRs, etc.**
- **1-on-1 Runs with Instructor Astronauts**
 - Done on a case-by-case basis
 - Significant improvement noted following these runs
- **4 Suit Joint EVA Runs --- infrequent due to NBL loading constraints**
 - Done to emphasize crew coordination and communication
 - Valuable experience according to students; leadership demonstrated
- **6 Hour Final Exam Run: high-fidelity flight simulation**
 - Simulated ultrabad day on ISS (multiple failing critical ORUs, bad comm)
 - Requires crew to develop timeline, and make real-time tradeoffs
- **DX32 Suited Runs: valuable experience for instructor group**

Student Expectations

- Prerequisite training (tools class, ISS Overview, EVA workbooks, observation of 1-2 skills runs) before the 1st run
- Punctuality - Be prompt for NBL prebriefs
- Treat each NBL run as a real EVA: don't use non-flight translation aids, don't be reliant on diver help, etc., etc.
- Conduct a thorough EVA prebrief using the cue card; use SFRM and teamwork
- Be receptive to constructive criticism from anyone willing to offer it, including the dive team
- Study the evaluators' comments from earlier dives, and strive to improve in those areas on subsequent runs
- Make the Program one of the highest priority activities on the calendar...



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General Observations

- Program met (and far exceeded) its initial goals
- Substantial gains in EVA skills and ISS familiarity noted
- Significant improvements in students' areas of weakness universally observed
- Students would often tend to plateau after 4-5 dedicated skills runs, if the runs were closely spaced; 6-10 runs remained the target, with some students requiring several more
- Frequent NBL runs: ideal time to perfect one's suit and glove fit
- Feedback was almost universally welcomed by students
- Runs required huge effort by DX and NBL teams



Lessons Learned

- 4-6 students/group was a good class size target number; larger groups took too long to graduate
- 3 hour runs were too short; 4 hours is now the standard length (building up to 6 hours by the time of the final run)
- Students who took the course the most seriously improved the most; heavy job tasking and travel noticeably affected performance
- Great exchange of ideas between CB & DX32
- Important to have the Lead IA and Lead DX32 Instructor spot check runs frequently for consistency in scoring

Lessons Learned (Continued)

- EVA Skills Development Program reinvented the way we train for EVA and spaceflight in general
- Robotics, Rendezvous and Shuttle Ascent/Entry modeled their training and evaluation tools after the EVA Skills Program
- Rookie EVAers began flight-specific training at a much higher level of performance than ever before
- Pool of EVA candidates grew significantly because of the skills program and we met the ISS Wall of EVA
- Participants got out of the program what they put into it, many “defying the odds”

Student Resources

- EVA Branch Homepage: <http://fcod/EVA/> [Not sure if this is still accessible]
 - EVA Prebrief Cue Card
 - RMS-EVA Voice Protocol
 - ISS EVA Labeling Overview
 - EVA Hardware and Ops Notes
 - A Brief History of ISS
- EVA Skills Video Series (Zane Ney, Chris Looper, Scott Parazynski)
- Small and Large Tools Classes (schedule in groups of 2-4, via Erlinda)
- EVA Tools and EMU Systems CD-ROMs/CBTs
- EVA Tools, EMU, Joint Airlock and SAFER Workbooks
- On-Board Training Products (CBT, Video): demonstrations of proper EVA techniques have been filmed in the NBL; will couple this with 1-G and flight EVA footage for all common skills and tasks in the near future
- EVA Exercise: the Astronaut Strength and Conditioning coaches can cater a program for you targeting EVA strength and endurance
- Watch real EVAs on NASA TV, and borrow videos from recent flights (WVS)

Motherhood Top 10 List

1. Give & receive constructive feedback well; take detailed notes; ask for diver feedback too [Destructive feedback is OK only if it's really funny]
2. Trust But Verify! [Fresh eyes should always question if things are being done properly/the best they can be]
3. Fess up if you screw up! [Avoid having MCC run down the wrong path if you know what really happened]
4. Understand what you're doing before you do it [Don't blindly turn a bolt or flip a switch w/o 1st understanding the consequences if you screw up]
 1. Know your EMU, SAFER and tools inside out
 2. Know your Payloads (mechanical, data, power, etc.) in depth
 3. Study your ESOP; watch EVA Skills Video Series
5. Try to make your teammates look good at all times (Crew, MOD, VITO, Boeing, XA) [If they look good, you'll look good]

Motherhood Top 10 List (Continued)

6. Let's make all our mistakes on the ground to the extent possible; once we make a mistake, let's quickly pick up the pieces & get back in the game
7. **Take initiative!** [You will be the experts your next flight]
 1. Attend EVA IPTs, NBL runs, VR runs as often as Alicia allows
 2. Help with suit ups at NBL, Prep & Post, SSATA
 3. Ask lots of questions of EVs and IVs who've been there before
 4. Watch EVAs from MCC SCA (3rd floor, near elevators)
 5. Watch your NBL run DVDs and those of your teammates
8. **Take ownership of all the tasks on the flight, regardless of your role (EV, IV, PDRS, ROBO)** [Your knowledge may save the day, & tasks may shift among the EVA days and crewmembers]
9. **Be fit --- or get fit!** [Treat EVA/flight preparation as if you were getting ready for the Olympic Gold Medal Round]
10. **No loitering!** [If you're not busy, EVA or IVA, think about what you can do to help your crewmates]

“Too Tall List of Motherhood” – UF-2

- **Begin your first EVA slow and controlled; stay slow and controlled until the end of EVA 3 [“Slow = Fast” should be your mantra]**
- **Verbalize critical steps (safety tether ops, connector status, PGT turns and torque) for IVA and MCC to follow along --- and be of greater value to you**
- **Keep comm. crisp and professional; minimize chatter during RMS maneuvers; a few “Wows” are OK, however**
- **Do a pull test on everything you install: sockets, APFRs, scoops**
- **“Make – Verify – Then Break” tether ops**
- **Stay hydrated in general, and particularly during EVA**
- **Don’t forget to take pictures --- they’re the only thing you can bring back from the walks!**

“Too Tall List of Motherhood” – UF-2

- **Keep good SA on helmet, boots, swingarm, PGT and tethers; cross-check your partner often**
- **“30 second rule” --- if you get a major tether snag, try to fix it yourself for up to 30”, then call your buddy for help**
- **Approaching a worksite, take a full mental image of the scene before getting tunnel vision on the task; pay attention to nearby connectors, cables, and other no-touch areas**
- **Always use some form of body restraint at a worksite (redundant waist tether, MWS end effector); null rates before beginning work**
- **You may find better body positions on-orbit than you had in the NBL due to 1-G effects --- be extremely cautious because you may not have thought about that grapple fixture or antenna that’s now at your feet...**

“Too Tall List of Motherhood” – UF-2

- **Don't dwell on errors or anomalies --- it's really no big deal (unless you lose the LEE!) --- keep your focus on the tasks at hand; MCC will be there to develop contingency plans if it's not on your crib sheet**
- **Fess up immediately if an error is made; unnecessary troubleshooting on the ground can ensue**
- **2-person rule for EMU prep and post; beware of fatigue-induced errors, especially at the end of the day (EVA cleanup, post EVA)**
- **Make sure to thank your EVA instructors and the hardware providers during your walks --- recommend writing names down on your cuff checklist as a memory jogger in case you get a bad case of “Space Brain”**
- **Have a Most Outstanding Adventure --- we'll be watching with envy...**

Under a Magnifying Glass

CB-QMS-TBD

Extravehicular Activity Evaluation Board Guide

Flight Crew Operations Directorate
Astronaut Office

December 2008

Basic



National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

- **Uncomfortable at first: Type A's like A's...**
- **Graduation from EVA Skills resulted in a determination of EVA eligibility (EV1, EV2, non-EVA)**
- **EEB: evaluated in-flight performance, assessed "promotion"**

Promoting More Time in the Water

2006 PEACOCK EVA SCAVENGER HUNT

- 4) TRANSLATE FROM THE SHUTTLE AIRLOCK UP THE AFT FACE OF PMA-2 (PRIME TRANSLATION PATH TO ISS). FIND PMA-2 WIF 14A ABOVE THE ORBITER DOCKING SYSTEM (ODS). LOOK CAREFULLY FOR NEARBY GRAFFITTI, WHICH SAYS: **[GO PEACOCKS]**
 - 5) HOW MANY "RETURN TO AIRLOCK" LABELS ARE LOCATED ON PMA2? **[2]**
 - 6) LOCATE THE 96 BOLTS THAT CAN BE RELEASED TO DISCONNECT THE ORBITER DOCKING SYSTEM FROM THE PAYLOAD BAY. WHICH BOLT NUMBERS ARE ON EITHER SIDE OF THE FLAT METAL GROUNDING STRAP? **[8&9]**
 - 7) TRANSLATE DOWN THE STBD SILL. WHO "WAS HERE"? **[CINDY]**
 - 8) MOVE TO THE AFT SHUTTLE BULKHEAD. HOW MANY HANDRAIL (HR) SEGMENTS DO YOU SEE (BETWEEN STANDOFFS)? **[7]**
 - 9) HOW MANY ELECTRICAL CROSSOVERS ARE ALONG EITHER SILL OF THE PAYLOAD BAY? **[6]**
- THAT WAS JUST A WARM UP. NOW SWIM OVER TO THE ISS MOCKUP, JUST OUTSIDE THE JOINT AIRLOCK, & LET'S GET GOING WITH THE REALLY TOUGH ONES!
- 10) IMAGINE YOU'RE EV1, JUST COMING OUT OF THE A/L. YOU'RE FACING ISS PORT, BASICALLY INVERTED IN THE POOL. YOUR SAFETY TETHER REELS WILL BE STOWED ON EYELETS HERE. WHAT IS THE HR# JUST INBOARD (ISS PORT) OF THE HATCH, IDEAL FOR SETTING UP A FISH STRINGER FOR TOOLS? **[0554]**

2 OF 13

2006 PEACOCK EVA SCAVENGER HUNT

The Challenge: Find as many answers as possible within the 3 hours allotted for this dive. It's quite likely you won't be able to answer every single question, **although we would like you to answer the very last question right before you finish your dive.**

Rules: you must turn in these sheets immediately at the completion of your dive to the Dive Supervisor (red vest); do not disconnect connectors or get in the way of other dive operations; stick with your Peacock buddy and work as a team; HAVE FUN!

To the Victors: Bragging Rights for 1 year, the respect and admiration of your peers and instructors, the honor of buying the first round at Pinche's (at the completion of the Peacock ASCAN flow), and a truly impressive trophy to display on your mantel.


PEACOCK-1: _____

PEACOCK-2: _____

DATE: _____

START TIME: _____ END TIME: _____

BEGIN ON THE SHUTTLE PAYLOAD BAY MOCKUP:

- 1) FIND THE STARBOARD (STBD) SPACE-TO-SPACE ORBITER RADIO (SSOR) ANTENNA. WHAT WORD FACES AFT IN THE PLB? **[EVA]**
- 2) DRAW THE SHAPE OF THE WIRELESS VIDEO RECEIVER ANTENNA: 
- 3) ENTER THE SHUTTLE AIRLOCK AND IMAGINE YOU'RE EV1, HEAD FACING DOWN AND AFT (FEET IN THE TUNNEL EXTENSION). YOU YAW RIGHT TO SEE THE DEPRESS VALVE, LOCATED ON WHAT PANEL: **[AW82A]**

1 OF 13

EVA Skills Feedback: Gold Standards

- Timeline Development:
- **5** Thorough, detailed plan including tool, tether and RMS operations; carried out T/L as planned
- **4** Well-organized overall; most details covered in plan, demonstrates reasonable ability to execute plan
- **3** Adequate big picture plan, but a few details left out; conducted T/L with some details omitted
- **2** Plan doesn't adequately cover complete task; requires some team coordination improvement
- **1** Superficial planning; major events omitted in plan or in conduct of run
- Comments:

EVA SKILLS DEVELOPMENT TRAINING EVALUATION FORM

Crewmember Name: _____ Date: _____

Instructor Astronaut: _____ NBL Run Length: _____

Test Conductor (optional): _____ Tasks Completed: _____

Filed By (circle): IA DX32 Position (circle): EV1 EV2 _____

Dive Partner: _____

Please thoroughly evaluate the crewmember's performance in each of the following areas, as applicable, and **provide explanatory comments for each category**. Cross out elements not demonstrated or relevant. If a particular element is done well by the crewmember, but the task was not especially difficult during the run (1 or 2 simple electrical connectors, for example), please score a "4" and make a note in the comments section to this effect. Return completed forms to Scott Parazynski, and feel free to call x48879 with any questions. Thanks for your participation!

Timeline Development:

- 5 Thorough, detailed plan including tool, tether and RMS operations; carried out T/L as planned
- 4 Well-organized overall; most details covered in plan, demonstrates reasonable ability to execute plan
- 3 Adequate big picture plan, but a few details left out; conducted T/L with some details omitted
- 2 Plan doesn't adequately cover complete task; requires some team coordination improvement
- 1 Superficial planning; major events omitted in plan or in conduct of run

Comments: _____

Airlock Egress/Ingress:

- 5 Excellent, clear communication and crew coordination; easily able to deal with tethers and stowed ORUs
- 4 Good egress from Airlock; able to determine most efficient egress; good teamwork
- 3 Some minor difficulties, but able to efficiently manage airlock operations; hits PLSS on egress
- 2 Not fully coordinated; a mild struggle with egress, tether operations and/or with ORUs
- 1 Needs significant improvement in comm, coordination or tether ops; potential damage to h/w or suits

Comments: _____

Team Communications (between EV crew, and with IV and RMS operator):

- 5 Clear, concise and constructive communication between all team members
- 4 Good communication, although could be more concise/precise with partner, RMS, IV or "MCC"
- 3 Able to communicate main ideas; no confusion but more thorough communication required
- 2 Some minor confusion due to lack of clear communications; needs to be a bit more/less assertive
- 1 Needs substantial improvement in clarity of communication, and/or needs to be more/less assertive

Comments: _____

Translation/Body Orientation/Spatial Awareness:

- 5 Excellent controlled method of translation; always aware of suit, spacecraft, tools, tethers, RMS and partner; does not kick or swim; does not fight the suit; does not hurry; comfortable in unusual attitudes
- 4 Very smooth translation; able to easily assume unusual attitudes in suit; very good situational awareness
- 3 Good translation; occasionally gets stuck or strikes neighboring h/w; ORUs/tools sometimes forgotten
- 2 Slightly awkward or slow translation; difficult body repositioning; loses track of location/ORUs/tools
- 1 Excessively slow translation; risks damage to self or h/w; unable to position for tasks; poor SA

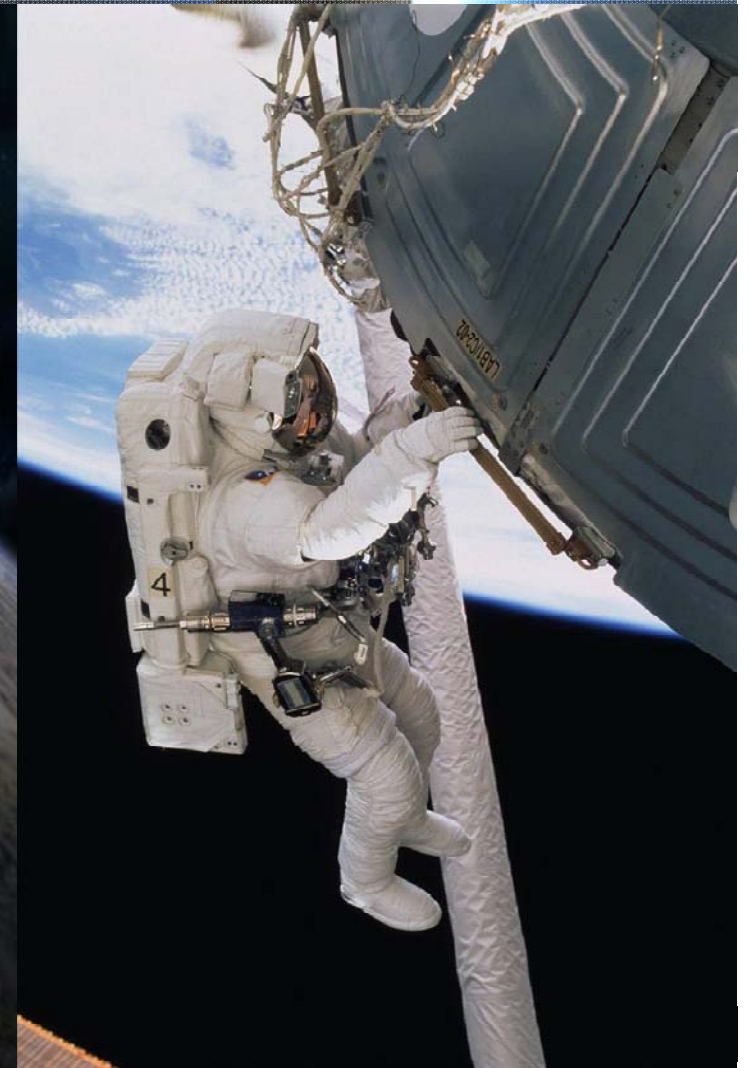
Comments: _____

Work Efficiency:

- 5 Thinks tasks through for maximum efficiency; works swiftly without being careless or taking any risk

EVA Skills Elements

- Airlock Egress/Ingress:
- **5** Excellent, clear communication and crew coordination; easily able to deal with tethers and stowed ORUs
- Team Communications (between EV crew, and with IV and RMS operator):
- **5** Clear, concise and constructive communication between all team members



EVA Skills Elements (Continued)



- Translation/Body Orientation/Spatial Awareness:
 - **5** Excellent controlled method of translation; always aware of suit, spacecraft, tools, tethers, RMS and partner; does not kick or swim; does not fight the suit; does not hurry; comfortable in unusual attitudes

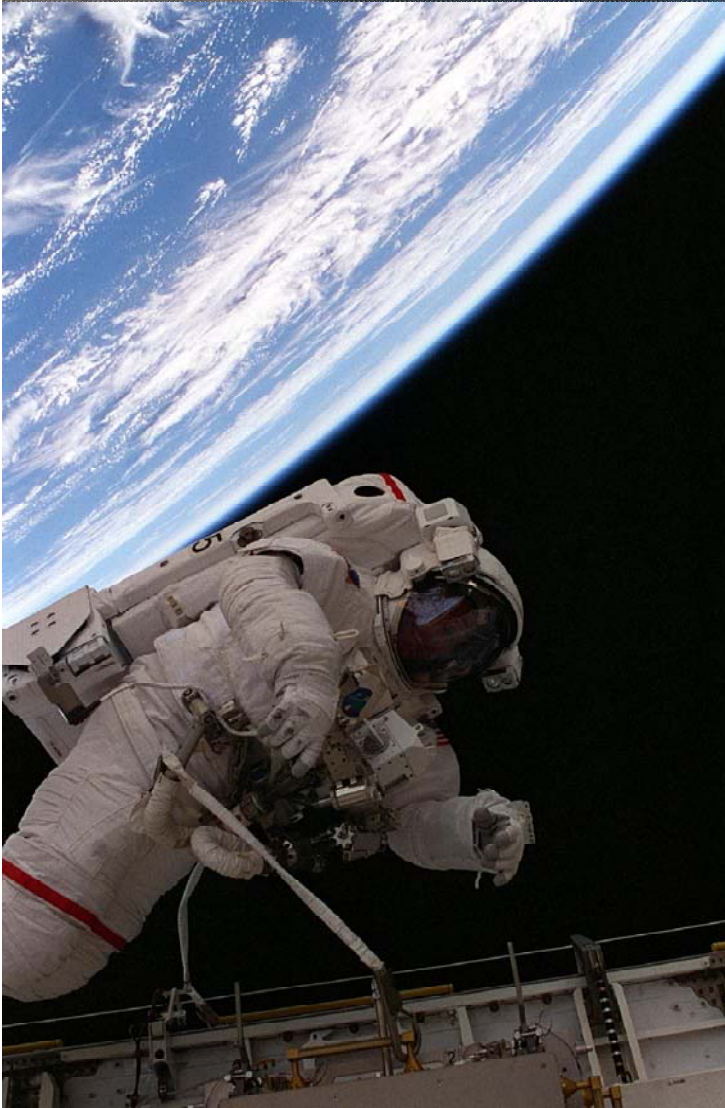
EVA Skills Elements (Continued)

- Work Efficiency:
- **5** Thinks tasks through for maximum efficiency; works swiftly without being careless or taking any risk
- Adaptability:
- **5** Quickly and appropriately reacts to off-nominal situations; excellent headwork
- General Attitude:
- **5** Responds very well to constructive criticism; takes immediate corrective action

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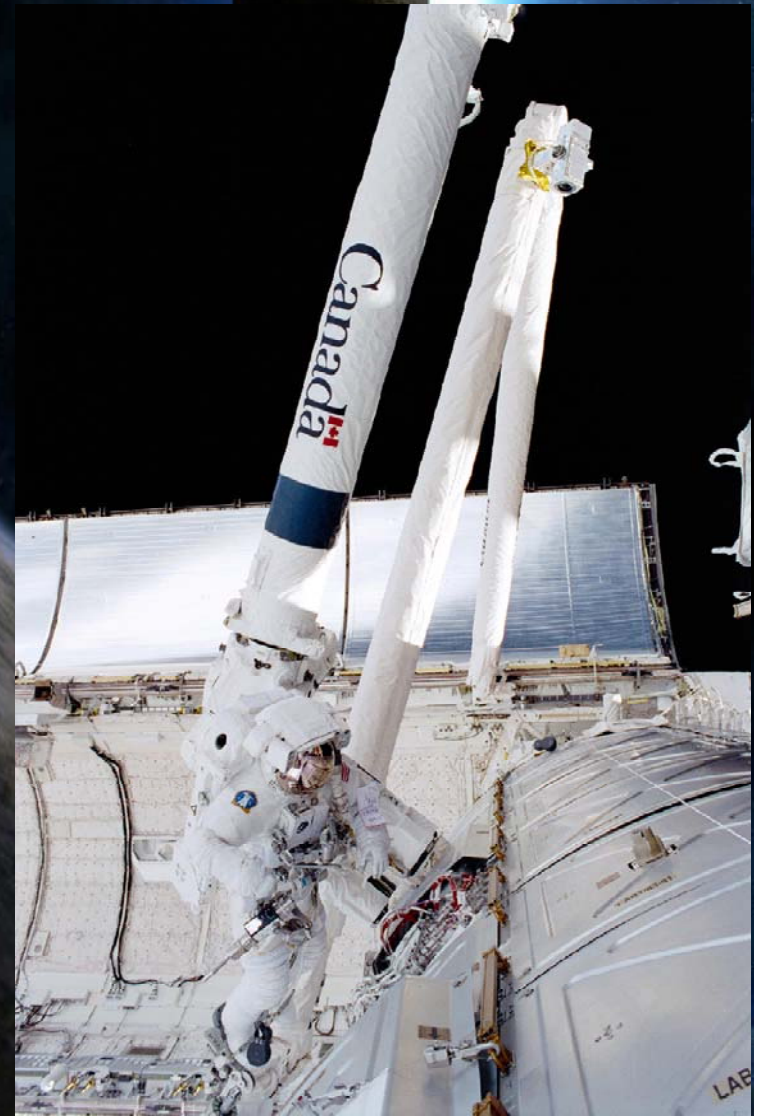
EVA Skills Elements (Continued)



- Tether Operations:
- **5** Frequently checks ERCM; always adheres to strict tether protocol; checks EV partner often
- PFR and Tool Stanchion Operations (if applicable):
- **5** Very easy installation, ingress, and reorientation of PFR; very comfortable with TS operations(if used)

EVA Skills Elements (Continued)

- PGT/Right-Angle Drive Operations:
- **5** Efficiently reconfigures PGT; precisely installs/operates w/o difficulty in close quarters; counts turns
- Body Restraint Tool (BRT) Operations:
- **5** Installs and uses the BRT with ease; translates/works without BRT impedance; keeps BRT in scan



EVA Skills Elements (Continued)



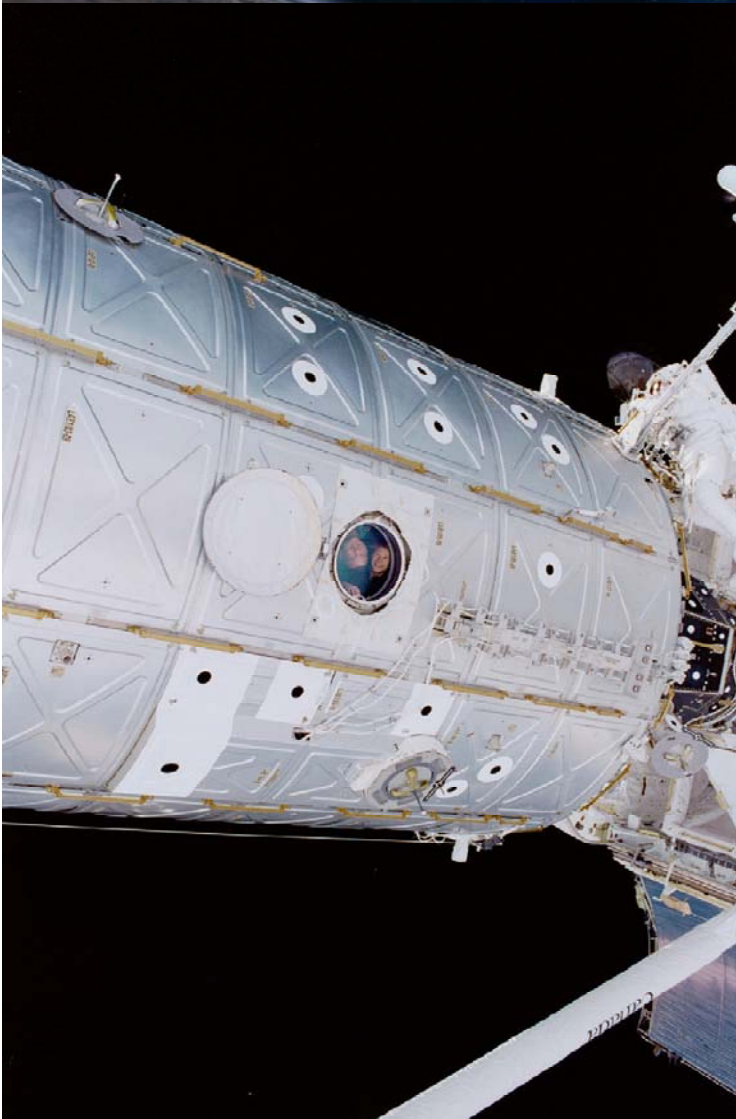
- Handling Aids: [circle those used: Microconical scoops D-handle]
- **5** Very easy and quick orientation, installation and use of the handling tools, with and without ORUs
- Electrical and Fluid Connectors:
- **5** Very easy to remove and install connectors from a variety of body orientations, and in confined spaces

EVA Skills Elements (Continued)

- Torque Multiplier:
- **5** Quickly and easily configured for use, installation and operation
- ORU Change-Out: [circle: DDCU Battery IFHX Other]
- **5** Excellent headwork, crew coordination, use of tools, tether protocol, body positioning, mass handling, spatial awareness (didn't hit structure or ORU), etc.



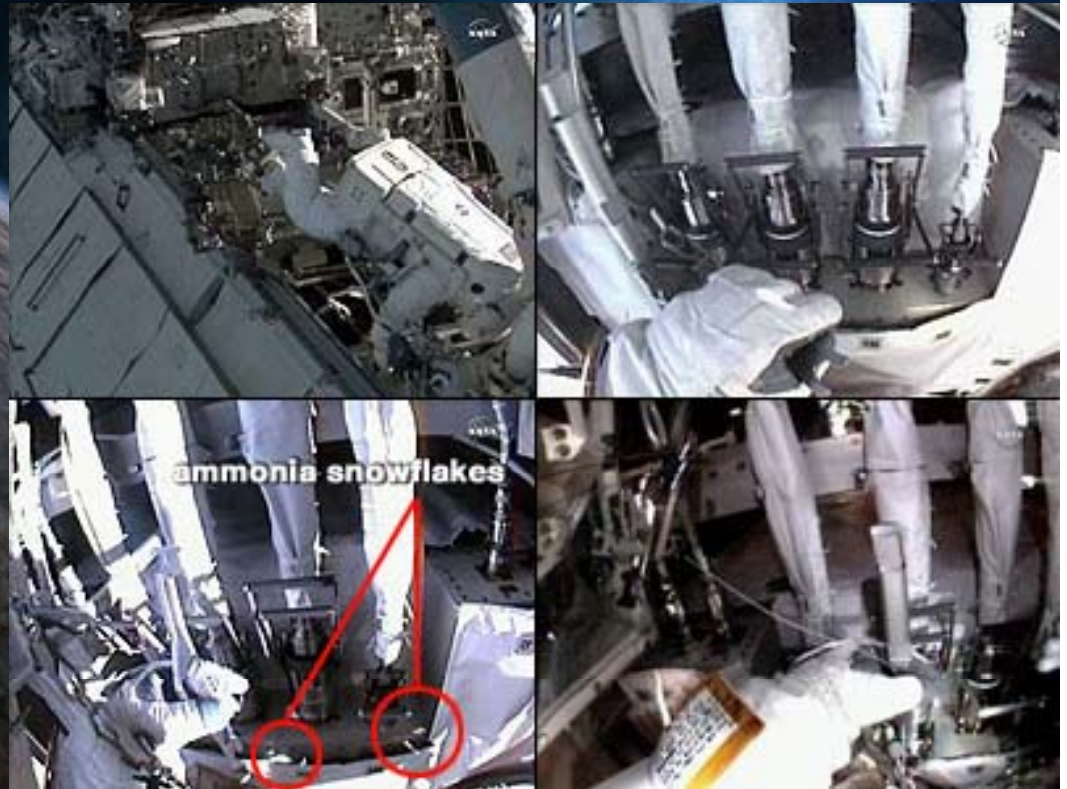
EVA Skills Elements (Concluded)

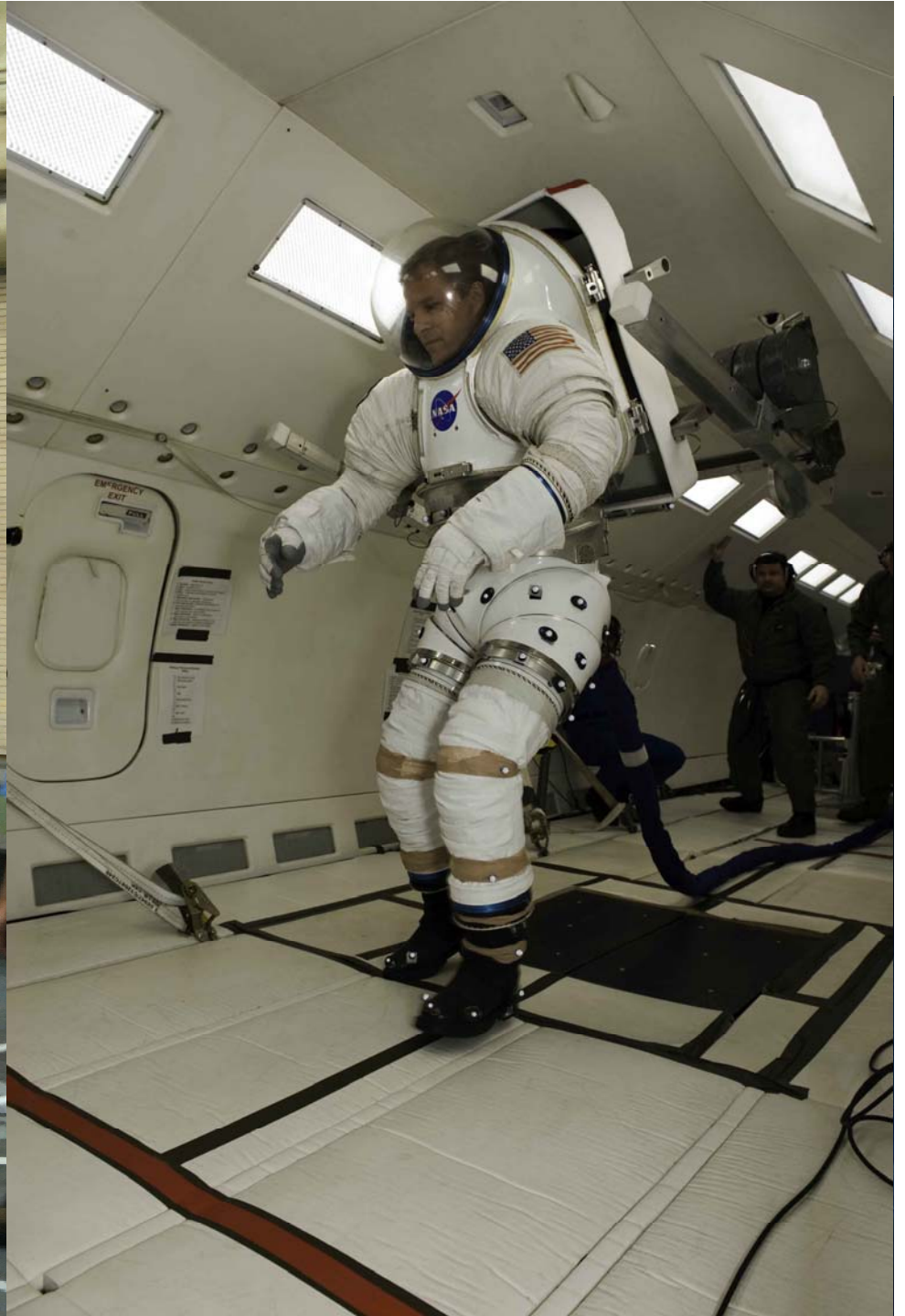


- 96-Bolt Contingency Task:
- **5** Excellent performance of entire contingency task; great teamwork
- Orbiter/RMS Contingencies:]
- **5** Excellent performance of entire contingency task; great teamwork
- EMU Suit Malfunctions:
- **5** Promptly/correctly works EMU cuff C/L to solve simulated suit mal; excellent crew coordination

Real World Validation of EVA Skills

- Stan Love on 1-E: Impromptu EVA 1
- Doug Wheelock on ISS (Pump Module R&R)
- Similar training and assessment tools used elsewhere:
 - PDRS & ROBO Quals
 - Shuttle Ascent/Entry
 - Rendezvous Quals
 - EVA & Robotic Assessments during Astronaut Selection







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Implications for the Future



- **Best to design the “suit system” up front:**
 - Tools & operations for ease of use and minimization of specialized training
 - Early operator involvement saves time and \$\$\$\$
- **Peak Performance:** can be attained by “setting the bar” & letting operators know where it is
- **Can be applied to many other operational environments**

QUESTIONS/DISCUSSION



Contact Info:

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